

APPLICATION UNDER UNITED STATES PATENT LAWS

Invention: **MESSAGE PLAYBACK CONCURRENT WITH
SPEAKERPHONE OPERATION**

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This is a:

- ☐ [] Provisional Application
- ☒ [X] Regular Utility Application
- ☐ [] Continuing Application
- ☐ [] PCT National Phase Application
- ☐ [] Design Application
- ☐ [] Reissue Application
- ☐ [] Plant Application

SPECIFICATION

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MESSAGE PLAYBACK CONCURRENT WITH SPEAKERPHONE OPERATION

BACKGROUND OF THE INVENTION

5 1. Field of the Invention

This invention relates generally to speakerphones including a voice messaging function. More particularly, it relates to the inclusion of a voice message playback signal together with a speakerphone signal in a telephone conversation.

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2. Background of Related Art

Voice messaging systems such as telephone answering devices are well known. A typical telephone answering device allows a caller to record a voice message for a user who fails to answer an incoming telephone call. Initially, voice messaging systems recorded voice messages onto magnetic cassette tapes. However, more recent voice messaging systems record voice messages into digital memory (e.g., typically non-volatile memory such as Flash memory).

To retrieve a recorded voice message, a user typically activates a PLAY function of the telephone answering device, either locally or from a remote location over a telephone line. In a remote access mode, the conventional telephone answering device replaces handset access to the telephone line with a signal path from the played back voice messages to the telephone line. In either case, the playback of a voice message is conventionally heard only by the user, either locally or at the remote location.

Oftentimes it is desired to share a particular voice message with someone else. To do so, the conventional user must call and verbally paraphrase or repeat the voice message which they played back for themselves. It is possible to playback a voice message and hold the

handset of a telephone toward the speaker of the telephone answering device, allowing an uncontrolled level of the played back voice message to be coupled into the telephone call between the user and the other person at the far end of a telephone call. Unfortunately, this typically
5 requires the user to take the handset away from their own ear, preventing the user from participating in a conversation with the far end party while picking up some level of the played back message.

There is a need for an improved apparatus and technique for allowing a user of a telephone answering device to share a recorded
10 voice message with another party.

SUMMARY OF THE INVENTION

In accordance with the principles of the present invention, a receive path of a voice messaging system with speakerphone capability
15 comprises a receive signal from a telephone line, a summer in the receive path, a gain module, and a message playback signal relating to a pre-recorded voice message. The message playback signal is combined with the receive signal by the summer, allowing simultaneous hearing by a local user of the speakerphone.

20 A method of allowing a playback message signal to be combined with a receive signal in a voice messaging system having speakerphone capability in accordance with another aspect of the present invention comprises hybrid echo canceling a transmit signal from a receive signal at a summer in a receive path of a voice messaging system
25 having speakerphone capability. A playback message signal is summed together with the hybrid echo cancelled signal at a point in the receive path after the summer. The speakerphone is maintained in a receive state until transmit activity is detected.

A method of playing back a recorded voice message in
30 accordance with yet another aspect of the present invention comprises

establishing a telephone call. A speakerphone function of a near end voice messaging device is initiated for the telephone call. A voice message recorded on the near end voice messaging system is played back while the telephone call remains established. An electrical signal corresponding to the played back voice message is injected into the telephone call such that individual users at either end of the telephone call can hear the played voice message and concurrently converse with one another as desired.

BRIEF DESCRIPTION OF THE DRAWINGS

Features and advantages of the present invention will become apparent to those skilled in the art from the following description with reference to the drawings, in which:

Fig. 1 shows a block diagram of an exemplary full-duplex digital speakerphone allowing combination of a played back voice message with a speakerphone conversation, in accordance with the principles of the present invention.

Fig. 2 shows a block diagram of an exemplary full-duplex digital speakerphone allowing conversational record during speakerphone operation, in accordance with the principles of the present invention.

Fig. 3 shows an exemplary process flow of the digital speakerphone/telephone answering device shown in Fig. 1 if no speakerphone conversation is present, the voice message will cause the speakerphone to transition to a receive Rx state, in accordance with the principles of the present invention.

Fig. 4 shows an exemplary process flow of the digital speakerphone/telephone answering device shown in Fig. 1 during a normal receive Rx to transmit Tx break-in condition during normal speakerphone operation, in accordance with the principles of the present invention.

Fig. 5 shows an exemplary process flow of the digital speakerphone/telephone answering device shown in Fig. 1 during a transmit Tx break-in during playback of the voice message, in accordance with the principles of the present invention.

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DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

The present invention allows simultaneous playback of a voice message recorded in a voice messaging system, e.g., in a telephone answering device (TAD), while using a speakerphone function of the telephone answering device. Simultaneous inclusion of both a speakerphone conversation and a played back voice message allows both parties to a telephone conversation to listen to the message at a controlled level and converse over the speakerphone at the same time.

Conventional echo canceling speakerphones incorporate Acoustic and Hybrid echo cancelers to eliminate or reduce Acoustic and Line echo respectively. In addition, both the transmit (Tx) and receive (Rx) paths (i.e., the microphone and speaker paths, respectively) have AGC (Automatic Gain Control) and Gain blocks which together perform a signal conditioning function for the conversation. In addition, two voice activity detectors, and Transmit and Receive switch guards or Ratio tests, are often used together with switching state logic to maintain stability and full duplex communication in a speakerphone conversation.

In accordance with the principles of the present invention, a message playback signal is incorporated into the conversation signal to allow the far end party to hear the voice message at the same time a local speakerphone user is hearing the voice message in a way which is controlled. The controlled combination of the conversation and message signals allows simultaneous conversation on the same telephone line as that used to transmit a voice message to the far end party.

In general, two telephone answering device functions can occur during speakerphone operation; conversation record, and playback of a previously recorded message or memo during speakerphone conversation. In accordance with the principles of the present invention, 5 conversation record multiplexes the microphone and line-in signals for recording on an appropriate medium, e.g., on magnetic tape or into digital memory (e.g., Flash memory).

The present invention provides that a recorded message can be played back and heard by the far-end party as well as over the 10 local speakerphone by the near-end party as if it were a normal receive signal. The present invention allows normal speakerphone operation to continue during this playback operation, allowing the far-end party and the near-end party to break-in over the message as desired and be heard by the other party.

15 It is preferred that both the message and conversation signals be at similar levels. However, the present invention relates equally to the suppression or amplification of either the conversation signal or the voice message playback signal. Moreover, it is preferred (but not absolutely necessary) that the message playback at the near end 20 be subject to the same speakerphone digital volume control at the far end.

Fig. 1 shows a block diagram of an exemplary full-duplex digital speakerphone allowing combination of a played back voice message with a speakerphone conversation, in accordance with the principles of the present invention.

25 In particular, in Fig. 1, a telephone answering device with speakerphone capability 10 includes a message playback module 140 which generates an otherwise conventional message playback signal, and a speaker 152 and microphone 150 forming the basis of a speakerphone.

The microphone 150 provides a signal to a buffer/amplifier 30 154, which then provides a signal to an analog-to-digital converter 102

(e.g., within a codec or similar device). The digitized microphone signal has audio echoes cancelled in a summer 192 using an acoustic echo canceller (AEC) in communication with the speaker path. This echo cancelled signal is fed to one side of a comparator 160, with the other side of the comparator 160 being sourced from the speaker path. The output of the comparator 160 is provided to a suitable controller 170 through an appropriate gain module 161.

A transmit voice activity detector 164 is in communication with the microphone path, and provides a controller 170 with a signal indicating the presence of transmit voice activity.

The digitized and acoustic echo cancelled microphone signal is amplified to a given desired level in an automatic gain control (AGC) amplifier 130.

A fixed gain block 144 provides additional gain for input to a switched loss/echo suppression module 174. The output of the switched loss/echo suppression module 174 is fed to a comparator 162, which also receives an input from the speaker path before it is digitally amplified. The output of the comparator 162 is fed to the controller 170.

The controller 170 may be any suitable processor, e.g., a digital signal processor (DSP), a microcontroller, or a microprocessor.

A hybrid echo canceller (HEC) 112 cancels the transmit signal from the received signal by adding an inverted representation of the transmitted signal to the received signal, appropriately delayed, in a digital summer 184.

A digital-to-analog (D/A) converter 106 provides digital to analog conversion of the microphone path signal for injection onto a telephone line 122 through a hybrid 120.

In a receive direction, a received analog signal from the hybrid 120 is input to an analog-to-digital (A/D) converter 104. The output

of the A/D converter **104** is added to an echo cancellation signal from the HEC **112**.

A receive voice activity detector **166** provides information regarding the presence of a received signal to the controller **170**.

5 The digitized and hybrid echo cancelled signal is amplified by an automatic gain control (AGC) module **132**. A digital gain module **146** provides further fixed gain as set, e.g., by a digital volume control. The output of the gain module **146** is input to a switched loss module **172**, which receives control information from the controller **170**. The output of
10 the switched loss module **170** is converted to an analog signal in a D/A **108**, and output by the speaker **152** of the speakerphone **10**.

Furthermore, in accordance with the principles of the present invention, a voice message playback signal is injected into the microphone (i.e., transmit) path for the benefit of the far end party,
15 preferably at a point before the HEC **112**. Also, or alternatively, the voice message playback signal may be injected into the receive path, i.e., into the local speaker path for the benefit of the near end party, preferably at a point after the HEC **112**.

In particular, the signal output from the message playback
20 module **140** is subjected to a fixed gain module **142**, similar to that provided by the gain module **144** in the transmit path and to the gain module **146** in the receive path. This provides a desired level to the voice playback signal for injection at a controlled level into the receive and transmit paths of the speakerphone.

25 Preferably, a separate gain block **142** is applied to the played back voice message. Preferably, the gain level of the gain block **142** is at the same or similar level as that in the speakerphone transmit Tx path to keep the played back message and the conversation signals at the same or similar level.

5 The level-controlled message playback signal is digitally combined into the transmit path using the digital summer 180 in the transmit path before the D/A converter 106, and is digitally combined into the receive path using the digital summer 182 after the A/D converter 104 in the receive path.

10 Message playback to the far end party is achieved by mixing the played back message signal from the message playback module 140 with the speakerphone transmit signal, preferably after the transmit signal conditioning blocks (e.g., the AGC 130 and gain module 144) and switched loss block 174.

The HEC 112 cancels any hybrid echo of the message from appearing in the receive path.

15 The played back voice message is also to be heard over the local speaker 152 by the near-end party, preferably at the same level as the far-end party's conversation is heard. In the disclosed embodiment, this is accomplished by combining the played back voice message signal into the receive path before the AGC 132 and gain block 146, but after the output from the HEC 112.

20 In this way, the receive path AGC 132 maintains both the far-end conversation and the played back voice message at the same level for output by the speaker 152. Moreover, the receive path digital volume control applies to both the level of the played back voice message as well as to the level of the conversation.

25 The Acoustic Echo Canceller (AEC) 110 is used to reduce the coupling between the microphone and the local speaker. The Hybrid Echo Canceller (HEC) 112 is used to reduce the hybrid coupling.

30 Both the transmit (Tx) and receive (Rx) paths have AGC (Automatic Gain Control) 130, 132 and gain blocks 144, 146 which together perform a signal conditioning function. The AGCs 130, 132 maintain a steady nominal output level with inputs over a much wider

dynamic range. The gain blocks **144**, **146** apply a fixed amplification or attenuation to the output of the AGCs **130**, **132**, respectively.

In the receive path the gain block **146** is used to implement digital volume control. In the transmit path, the gain block **144** is used to
5 maintain the required transmit level to the telephone line **122**.

Both the transmit Tx and receive Rx paths have a switched loss block **174**, **172**, respectively, to maintain loop stability. In the transmit Tx path, the switched loss module **174** also includes echo suppression to provide residual echo control.

10 To overcome the switched loss in the receive path, the speakerphone **10** is preferably artificially forced to a receive state. For instance, this may be handled by forcing the line-ratio comparator **162** to indicate a receive condition during message playback. To those skilled in the art, the term "line-ratio" is also known as "receive switch guard".

15 With the telephone answering system shown in Fig. 1, the far-end signal can be heard over the local speaker **152** mixed in with the playback of a voice message, all at a level adjusted by the digital volume control **146**.

A simultaneous presence of the played back message
20 together with a far-end signal (determined by the receive voice activity detector **166**) maintains the speakerphone **10** in a receive state. A sufficiently loud near end signal would cause the speakerphone **10** to break-in from a receive state to a transmit state. In the transmit state, the transmitted microphone signal is mixed with the signal from the message
25 playback module **140** and heard at the far-end.

Accordingly, in order to transmit the message to the far-end, the voice message is combined at some point in the transmit Tx path. If the played back voice message signal is combined before the switched loss echo suppression module **174**, then the transmit Tx path should be
30 kept active during the playback of the voice message. Otherwise, the

voice message will not be heard at the far-end. However, because it is preferred to keep the transmit Tx path inactive and the receive Rx path active during playback of the voice message to allow the far end to hear the message playback, the voice message signal is preferably added in
5 after the switched loss echo suppression module 174 as shown in Fig. 1.

The message playback will affect only the line-out input to the line-ratio (LR) comparator 162.

It is also preferred that the voice message being played back be heard over the local speaker 152 by the near-end party, at the
10 same level as the far-end conversation. In accordance with the principles of the present invention, this can be handled by combining the voice message signal in the transmit Tx path before the AGC 132 and gain block 146 in the receive Rx path, but after the output of the HEC 112, as shown in Fig. 1. The AGC 132 maintains both the far-end conversation
15 and the played back voice message at the same level.

The receive Rx digital volume control 146 preferably applies to both the played back voice message and to the conversation.

In Fig. 1, the message playback signal is presented to a fixed gain module 142. However, this presumes that the recorded
20 message (e.g., a conversational record message or a voice message received from a caller) was processed through an automatic gain control (AGC) module before it was recorded.

For instance, Fig. 2 shows an exemplary system diagram showing signal flows allowing conversational record during speakerphone
25 operation. In accordance with this aspect, a conversational record feature is used to record a voice message in suitable voice message memory for playback through the message playback module 140. Of course, the principles of the present invention relate equally to an AGC module placed after the voice message is recorded, e.g., between the message playback
30 module 140 and the fixed gain module 142.

Figs. 3, 4 and 5 show exemplary switching state diagrams of a digital speakerphone such as the one shown in Fig. 1, in accordance with the principles of the present invention.

In particular, in the state diagrams of Figs. 3, 4 and 5, ME refers to the output of the Tx VAD (Transmit Voice Activity Detector) 164 shown in Fig. 1, LE to the output of the Rx VAD 166 shown in Fig. 1, LR to the decision of the Line-Ratio comparator test 162, and AR to the decision of the Acoustic-ratio comparator test 160. ME and LE refer to a speech activity decision as well as to an energy level when comparing ME and LE.

Referring back to Fig. 1, the playback of the voice message forces the output of the receive voice activity detector 166 to become active, e.g., $LE=1$, and forces the output of the line-ratio comparator 162 LR to be equal to R (i.e., in the receive Rx state). Also, the output of the transmit voice activity detector 164 becomes active, e.g., $ME=1$, and the output of the acoustic ratio comparator 160 becomes $AR=R$.

Fig. 3 shows that if no speakerphone conversation is present, the voice message will cause the speakerphone 10 to transition to a receive Rx state.

In accordance with the principles of the present invention, the far-end signal can be heard over the local speaker 152 mixed in with the played back voice message. A simultaneous presence of the far-end signal will maintain the receive activity condition active, e.g., $LE=1$ and $LR=R$, and will maintain the speakerphone 10 in a receive Rx state.

Fig. 4 shows an exemplary process flow of a normal receive Rx to transmit Tx break-in condition during normal speakerphone operation.

Fig. 5 shows an exemplary process flow of a transmit Tx break-in during playback of a voice message on a speakerphone as shown in Fig. 1.

As shown in Figs. 4 and 5, a sufficiently loud near-end signal will cause the output of the acoustic ratio comparator 160 to indicate a transmit condition, e.g., $AR=T$ and $ME=1$. If $ME>LE$, then the speakerphone 10 switches to a transmit Tx condition. The microphone
5 signal will then be mixed with the played voice message signal and heard at the far-end.

The concurrent capability of voice message playback combined with a conversation signal allows parties involved in a speakerphone conversation to jointly participate in listening to a message
10 recorded on one party's telephone answering device, while at the same time continue their conversation using the speakerphone.

While the invention has been described with reference to the exemplary embodiments thereof, those skilled in the art will be able to make various modifications to the described embodiments of the invention
15 without departing from the true spirit and scope of the invention.

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